DOCUMENT RESUME

ED 365 801 CE 065 407

TITLE An Inventory of Skills and Knowledge Necessary for a Career as a Data Processing Equipment Maintenance Technician, Computer Technician, or Computer Repairer.

INSTITUTION Hawaii State Board for Vocational Education, Honolulu.; Hawaii State Dept. of Education, Honolulu. Office of the Director for Vocational Education.

PUB DATE Aug 93

NOTE 24p.; Prepared by the Statewide Technical Committee on Computer Repairer.

PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *Computers; Data Processing; *Educational Needs; Employment Qualifications; *Equipment Maintenance; High Schools; *Job Skills; *Machine Repairers; Occupational Information; *Office Machines; Postsecondary Education; Statewide Planning; Technical Education; Two Year Colleges

IDENTIFIERS *Hawaii; Tech Prep

ABSTRACT

In response to a mandate in the 1984 Perkins Act, representatives of Hawaii's computer/data processing industry and state council on vocational education formed a technical committee to develop an inventory of the skills and knowledge necessary for a career as a data processing equipment maintenance technician, a computer technician, or a computer repairer. Relevant materials available from other states were reviewed. A preliminary inventory was drafted by State Board for Vocational Education staff and then revised three times after a group meeting and person-to-person interviews. The following issues were considered during the development process: future directions of the industry, employment opportunities, the amenability of computer repairer curricula to being converted to a 2+2+2 training configuration, and new skill technologies. The inventory ultimately developed contained 108 skills in the following areas: fundamentals of data processing equipment and general systems; system architecture; central processing unit architecture and timing; tools and test equipment; buses, protocols, and handshakes for input/output operations and communications; generic troubleshooting; miscellaneous concerns; safety; knowledge of software; and attitudes and social skills. (Appended are data on employment opportunities for computer repairers in Hawaii.) (MN)

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AN INVENTORY OF SKILLS, KNOWLEDGE AND ATTITUDES NECESSARY FOR A CAREER AS A DATA PROCESSING EQUIPMENT MAINTENANCE TECHNICIAN, COMPUTER TECHNICIAN, OR COMPUTER REPAIRER

Provided by the
State-wide Technical Committee on
Computer Repairing

August, 1993

State Board for Vocational Education

Acknowledgments

The members of the Technical Committee on Computer Repairing were selected with the assistance of the Vocational Education Coordinating Advisory Council and well-known persons in the data processing field. The members were nominated officially by the State Director for Vocational Education, Dr. Alan Kohan.

Those selected and who served on the Technical Committee were:

Mike Willingham
Vice President, Manager FE Division
ASC Hawaii

Warren T. Bingo
Branch Manager
Bell Atlantic Business Systems Services

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Electronics Hawaii, Inc.

Paul De La Cruz
Tech Repair
Computer Sales/Technical Support

Roy Tsumoto
Department of Education
Occupational Development Section

Introduction

For those readers who have read each of the preceding 12 reports prepared by technical committees, much of the preliminary information will seem familiar. It is necessary to repeat this information for readers unfamiliar with the earlier inventories which were circulated statewide. These earlier inventories can be copied for use by individuals or groups on request by the Office of the State Director for Vocational Education. The original printing of most skills inventories has been exhausted. Occupations previously studied are as follows:

- Electronics
- Automotive Technology
- Child Care
- Gerontology
- Computer Programming
- Graphic Arts
- Accounting
- Diversified Agriculture
- Food Service
- Drafting
- Office Administration and Technology (Secretarial Occupations)
- Nurses Aide

The Carl Perkins Education Act of 1984, PL 98-524, had two major themes: access to training for special populations, and "program improvement." The inventories prepared prior to 1990 were designed to meet the objective of "program improvement." The 1990 Carl Perkins Vocational and Applied Technology, PL 101-962, placed primary

emphasis on assistance to special populations. However, there is reference to program improvement. In section #235, of this law it is required that:

> (a) **GENERAL AUTHORITY.**--Each eligible recipient that receives a grant under this part shall use funds provided under such grant to improve vocational education programs, with the full participation of individuals who are members of special populations, at a limited number of sites or with respect to a limited number of program areas.*

As a consequence, this document as those prepared under the preceding law, PL 98-524, is addressed at providing educators and other interested parties with an additional resource to facilitate program improvement.

Under the Carl Perkins Law of 1984, the mandate given to the prescribed technical committees was to develop curriculum paradigms for existing programs by which the relevance of on-going instruction might be made measurable. It would appear that the same emphasis was also intended at examining the job training objectives under the new law. In Section 111 (g) of PL 101-962 it is required that:

> (g) Each State board, in consultation with the State council, shall establish a limited number of technical committees to advise the council and the board on the development of model curricula to address State labor market needs. Technical committees shall develop an inventory of skills that may be used by the State board to define state-of-the-art model curricula. Such inventory will provide the type and level of knowledge and skills needed for entry, retention, and advancement in occupational areas taught in the State. The State board shall establish procedures for membership, operation, and duration of such committees consistent with the purposes of this Act. The membership shall be representatives of.... **

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* Our emphasis underlined portion.
** Our emphasis underlined portion.

Composition and Selection of the Membership of the Technical Committee for Computer Repair

Usually it is somewhat difficult to form such a committee that is both representative of the industry as a whole and that has sufficient expertise in all of the aspects of the occupation. Most firms that deal with computers in Hawaii are primarily concerned with sales and marketing. These firms may also provide some routine, scheduled maintenance to those who purchased their equipment. It was decided to concentrate only on those firms that dealt primarily with the repair of defective or faulty data processing equipment. The yellow pages of the GTE Hawaiian Telephone Book were used to identify such firms. Every relevant heading, "rubric," and or description was pursued. The resulting universe was fairly small.

All firms that performed computer repairs as their principal functions were contacted on Oahu. One outer island firm was contacted. Attempts were made to contact all firms that could be described as meeting this principal criterion on Oahu. Only one firm declined to participate. A couple of companies could not be contacted successfully.

Unfortunately, because of the limited number of participants involved, there was no other population against which to validate the inventory developed by the committee. The committee members and their respective firms can be identified on the acknowledgment page found at the outset of the paper or inventory. The State Council on Vocational Education (SCOVE) was also consulted in the selection process. SCOVE nominated a representative who agreed to serve. Because his business is located in Hilo, his input came primarily via phone calls and FAX.

The two operating agencies were also invited to provide a representative to guarantee that whatever the group proposed was pedagogically feasible.

Most firms were small in size, in terms of number of employees. Some involved one or two person operations. There were no female computer repairer employer by the firms contacted. Some firms serviced only one or two brands or manufacturers. Most tried to cover the full range of data processing equipment available in Hawaii.

Concerns

As had previously mentioned, only those who viewed "repair services" as the heart, their business activities were considered. One firm declined to participate and some could not be contacted. Those who participated represented the best universe possible, given the logistical and financial constraints of the project.

Methods Employed

A review of relevant materials available through the auspices of other states was facilitated by the Western Curriculum Coordinating Center. The staff representative of the State Board for Vocational Education, developed a preliminary "inventory" of the knowledge, skills, and attitudes that appeared to be necessary for successful participation in the Computer Repairer field. Using this draft as a springboard the committee developed and revised three versions of the inventory. Many redundant and some archaic items were deleted. Other additional criteria were added and there was a good deal of rewording and reorganization of items. As in previous studies, some of the curriculum guides reviewed emphasized "knowledge" and others "skills." The technical committee sought to provide a balance in their selection of items.

There were four different contacts attempted with the committee participants by the OSDVE facilitator. At the first meeting, which was on a one-to-one basis, the facilitator explained the purpose of the project. He, subsequently, provided a preliminary version of an inventory taken from numerous curriculum files which could serve as the focus for mark-up and revision.

The second contact involved a group meeting. At this meeting there was a healthy and spirited exchange of ideas and expression of priorities. Generally speaking the group felt:

(1) There was too much redundancy in the preliminary inventory.

(2) Some of the items needed to be reorganized into different categories.

(3) The general terms "microprocessor" and "microcomputer" were dated. These terms were used in the 1980's. Today there is too much overlap between "free standing" units and mainframe arrangements. The terms "computer processing unit" (CPU) and "system" were deemed more appropriate descriptors given most situations.

The committee members also felt the following considerations should be addressed somewhere in the inventory. They felt that:

(1) Mechanical and psychomotor skills should be mentioned. Someone entering the field should be able to look at a piece of equipment, take it apart and rebuild it in the proper sequence, having located and solved the problem.

(2) Special attention should be devoted at solving the problems of "moving parts." Problems with moving parts make up between 70 to 95 percent of most equipment failures. Most electronic malfunctions over 95% can be identified with circuit board monitoring equipment. Correction of these

problems usually involves the simple replacement of the defective component.

(3) The topic of fiber optic cables should be given more attention in future curricula. Fiber optic cables will soon be in general use.

(4) New curricula should also place emphasis on subject matter in the areas of "digital" and "AC/DCs".

(5) Prospective technicians should not be dissuaded from entering the field because of fear of extensive mathematics requirements. While an extensive background in algebra, trigonometry, geometry and calculus is necessary for a career in electrical or mechanical engineering, it is not necessary for most positions described as electronic technician or computer repairer.

(6) Computer repairers need some knowledge of software (e.g. programs).

The third go-around involved person-to-person interviews once again. Numerous minor changes were suggested and were incorporated in the third revision. However, the major concerns expressed were:

(1) Shocks can apparently occur when a technician is working on a terminal tied to a mainframe and other similarly joined terminals are in use. Shocks can also occasionally occur when technicians work on cables connecting equipment physically located at different elevations.

(2) All computer repairers, whether they are generalists or specialists, should be familiar with all aspects of system's design.

(3) Most attitudes and personality characteristics are formed in childhood by family and peers. While good attitudes are essential, teachers of future computer repairers should not take personal responsibility for major personality alterations.

Further changes to the inventory were made by phone and letter after committee members received the third revision.

Issues

(1) Future Directions of the Industry. Most prediction models are based on historical trends and often do not anticipate changes in technology. As data processing equipment are almost constantly being updated, the change is often radical and frequently unanticipated by the user market.

Thirty years ago computers consisted predominantly of grids of wires with magnets attached at intersections that were charged to indicate a "0" or "1" reading in the most simplistic binary fashion. Assembler or translation programs were needed even to interpret basic programming languages. The arrangement was not user friendly.

Most input took place using punched cards and bulk locating was the mode. Output consisted primarily of printouts and there was very little interaction between the program and the operator. By today's standards, the process was slow and the machines cumbersome.

Today most of the equipment is "interactive". The operator can alter the output desired during the final stages of processing. The equipment is more compact and makes extensive use of such things as micro chips and semi-conductors. The analysis process is displayed on a cathode ray tube (CRT).

Some equipment is free standing with the CPU enclosed and independent of other analytical components. Some terminals or keyboard stations may be tied to a central "mainframe" which performs most of the CPU functions.

As input mechanisms, such as keyboards and the manipulative or moving parts, become more simple in design, fewer repairs may be necessary. Some manufactures have even proposed arranging all electronic circuits on a single circuit board. With this arrangement, to repair one small malfunction in a CPU, the entire board would have to be replaced. Skilled operators might well do this themselves. In fact, if prices for equipment that are primarily used for "word processing"* decline, it may become feasible to replace the entire unit if a single component fails.

If networks become centralized into state-wide or island-wide networks, some types of adjustments and repairs may be possible from a central location, much like the practice now followed in the TV cable industry. However, computer repairers, would probably still be necessary for analysis and consultation.

In the near future, the industry will probable by configured much as is today. Sales outlets will still provide routine, scheduled maintenance. The repair of computers, that have failed, will still be left to small agencies staffed by a relatively small number of skilled technicians.

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* A state of the art word for modern typewriting.

Technicians will have to refer to industry bulletins even more diligently as change continues to accelerate. All will need to be familiar with fiber optics as this mode of communication replaces traditional cables.

(2) Employment Opportunities according to data provided by the Hawaii State Occupational Information Center (see Appendix A) and industry people, employment opportunities in the industry will remain fairly constant. This trend might be altered, if there was a major relocation to Hawaii of firms having large data processing and communication requirements. Such an occurrence might increase the volume of business. However, the high cost of living in Hawaii must be contained and even substantially reduced if any industry other than tourism is to be attracted to the state.

On the other hand, relatively simple computers, such as those used for typewriters or word processing, may become disposable items. If it breaks replace it instead of repair it may be the norm for companies with large numbers of terminals. Given a working life of 3 - 5 years, the equipment is likely to be obsolete when the first major electronic failure occurs. Computer repairers might then be relegated to making adjustments on moving parts or replacing entire central processing units.

(3) The Amenability of "Computer Repairer" Curricula As Being Converted To A 2+2+2 Training Configuration. As reported by Dr. Ned Weldon of the Technical Committee on Electronics, a few years back, the professions of electronics technician and electrical engineer require significantly different patterns of preparation. The electronics technician or computer repairer must be able to disassemble a piece of complex equipment, trouble shoot it,

and put it back together in working order. Comparatively little advanced math is required.

An electrical engineer need not be highly schooled in the mechanical aspects of computer equipment per se, but he or she must have a thorough understanding of high level mathematics. He or she may not need to have a high level of psychomotor ability or understand the physical relationships of the various components of a given piece of electronic equipment. However, that person must understand and apply the theoretical knowledge he or she possesses in the conceptual design process.

In general, the members of the Technical Committee on Computer Repairer would tend to agree with Dr. Weldon. The preparation for the two professions is markedly different, and one cannot easily change his or her career orientation mid-way through the professional preparation process.

The existing electronics program at the high schools will have to be modified if it is to be compatible with even a 2+2 program in the area of computer repairer.

(4) New Skill Technologies. As mentioned earlier the data processing field is changing constantly. No one can accurately chart its precise direction. It is known that as "super semi-conductors" come into play the technology may again experience major changes. Therefore, it is imperative that Computer Repairers acquire the basic and technical skills needed to adapt to emerging technologies work methods, and new world markets.

What follows is the heart and essence of this report. It is the product of the Technical Committee and represents the best thinking of those in the local industry as of the date of this printing.

INVENTORY OF BASIC SKILLS, KNOWLEDGE AND ATTITUDES FOR DATA PROCESSING EQUIPMENT MAINTENANCE TECHNICIAN, COMPUTER TECHNICIAN, OR COMPUTER REPAIRER

*I. CRITERIA - FUNDAMENTALS OF DATA PROCESSING EQUIPMENT AND GENERAL SYSTEMS

*1. Match terms related to fundamentals of computing systems with their correct definitions.

2. Match electricity/electronics areas with their definitions.

3. Understand the functions concerning various sections of a CPU and be able to explain them to a computer terminal operator.

4. Solve problems concerning system architecture and information flow.

5. Solve problems concerning decoding techniques and their characteristics.

6. Complete statements concerning other functions of the control section.

7. Match specific registers with their functions.

8. Match status bits or flags with their functions.

9. Understand busses and what they do.

10. Solve problems concerning the clock and clock circuitry.

11. Understand stack operations.

12. Be familiar with interrupts and how they work.

13. Have knowledge of I/O devices and their functions.

14. Solve problems concerning structured programming and its objectives.

15. Be familiar with programming models and their uses.

16. Be cognizant of memory mapping.

17. Match programming activities with their functions.

18. Solve problems concerning system operations.

* Indicates new criteria or rewording

19. Fill in a block diagram of a CPU.
*20. Familiarity with all aspects of a computer's operation even if trained to be a specialist.

II. CRITERIA - SYSTEM ARCHITECTURE

1. Match terms related to system architecture with their correct definitions.
2. Understand the importance of system control functions.
3. List the busses on a typical CPU.
4. Be familiar with the characteristics of the data bus.
5. Know the characteristics of the address bus.
6. Understand the characteristics of the control bus.
7. Have knowledge of the characteristics of the system bus.
8. Be cognizant of busses and I/O relationships.
9. Be familiar with ROM's and their characteristics.
10. Be knowledgeable regarding read/write memories (RAM's) and their characteristics.
11. Show demonstrable knowledge regarding timing circuits.
*12. Have a working knowledge of timing signals.
13. Solve problems related to system architecture and bus activity.
14. Diagram the relationship between the microprocessor and other system components in typical system architecture.
*15. Service "break out box."
*16. Working knowledge of synchronous and asynchronous functions.

III.CRITERIA - CPU ARCHITECTURE AND TIMING

1. Match terms related to microprocessor architecture and timing with their correct definitions.
2. Differentiate between major elements of a system architecture.
3. Demonstrate an understanding of the system architecture.

4. Understand the architectural features of computers.
5. Understand the architecture of a microprocessor.
6. Demonstrate a detailed understanding of the architectural features of a CPU.
7. Complete comparisons between various systems.
8. Demonstrate an understanding concerning features that enhance system performance.
9. Solve problems concerning waveform interpretations.
10. Interpret a typical cycle for reading data from memory or peripherals.
11. Interpret a typical cycle for writing data to memory or peripherals.
12. Demonstrate a knowledge of instructions that move data.
13. Be knowledgeable with instructions for arithmetic and logic functions.
14. Indicate an ability to deal with instructions for decision making.
15. Know instructions for special operations.
16. Match addressing modes with their characteristics.

IV. CRITERIA - TOOLS AND TEST EQUIPMENT

1. Match terms related to tools and test equipment with their correct definitions.
2. Demonstrate standard hand tools for microcomputer repair.
3. Demonstrate techniques involving the use of soldering equipment.
4. Know about lubrication tools and materials.
5. Complete a list of inspection and cleaning tools.
6. Be knowledgeable about static control devices.
7. Be knowledgeable about power supplies.
8. Deal with DVOM operations.
9. Demonstrate ability with oscilloscope operations.
10. Show ability to deal with data analyzer operations.
11. Demonstrate the ability to:
    11.1 Use a DVOM.

11.2. Be able to use an oscilloscope.

*V. CRITERIA - BUSSES, PROTOCOLS, AND HANDSHAKES FOR BOTH INPUT/OUTPUT OPERATIONS" AND COMMUNICATIONS"

1. Match terms related to busses, protocols, and handshakes with their correct definitions.
2. Match system busses with their characteristics.
*3. Solve problems concerning EIA pin specifications.
4. Select true statements concerning relationships with DCE and DTE devices.
5. Have knowledge of data transfer processes.
6. Have knowledge of serial and parallel transfer mechanisms.
7. Know about the types of cables used on most computers.
8. Be able to demonstrate cable assembly techniques.
9. Be familiar with the special tools required for cable assembly.
10. Complete a list of special materials for cable assembly.
11. Arrange in order the steps in documenting cable assemblies.
12. Demonstrate the ability to assemble cable connectors.

VI. CRITERIA - GENERIC TROUBLESHOOTING

1. Complete a list of troubleshooting preliminaries.
2. Be cognizant of the rationale and order of systematic troubleshooting.
3. Know how to use troubleshooting diagrams.
4. Be able to use flow charts and their characteristics.
5. Understand schematics.
6. Demonstrate the ability to extract pins and remove chips from a printed circuit board.
7. Repair a faulty clock.

VII. MISCELLANEOUS CONCERNS

1. Have reasonable mechanical ability (e.g. be able to take a piece of equipment apart, identify the problem, and restore it to working condition).
2. Have operational knowledge of AC/DC.
3. Have operational knowledge of digital technology.
4. Good familiarity with fiber optics.
*5. Knowledge of storage devices (e.g., floppy disks, hard drives, optical, tape drives, etc.)
*6. Knowledge of video devices such as monochrome.
*7. Familiar with operating systems (DOS, 05/2, Xenix, Unix, etc.)
*8. Understand and be able to make proper use of procedures for handling static sensitive parts (e.g., grounding straps, grounding mats, etc.)
*9. Ability to see patterns in equipment which facilitate more expedient trouble-shooting.
*10. Read industrial and manufacturer bulletins on a regular basis.

VIII. SAFETY

*1. Electrical shock awareness
*2. Recommend appropriate office, work stations conditions (e.g., elimination of haphazard arrangement of cords, proper lighting, etc.)
*3. Awareness of the importance of heeding "warning" labels in disassembly of systems and components.
*4. Familiarity with proper procedures for disposing CRTs.

IX. KNOWLEDGE OF SOFTWARE

X. ATTITUDES AND SOCIAL SKILLS

1. Ability to communicate effectively with client.
2. Ability to function effectively with associates and coworkers.
3. Dependability.
4. Adaptability.

5. Motivation.
6. Team player.
7. Self-starter.
8. Pride in work.
9. Honesty.
*10. Eager to learn.
*11. Enthusiasm.
*12. Good customer relations.
*13. Ability to ask right questions of terminal operator for diagnostic purposes.
*14. Desire.

APPENDIX A

Employment Opportunities
for Computer Repairers

Hawaii SOICC
Department of Labor and Industrial Relations (HSOICC)

Most Recent Data

	1988	1993	Open/yr*
HOEPS equivalency for Computer Repairer			
Data Processing Equipment Repairers	290	360	14

* Open/yr refers to the annual job openings experienced between 1988 and 1993.